Claims

We claim:

1. An indirect calorimeter for measuring the metabolic activity of a subject comprising:

a respiratory connector operative to be supported in contact with the subject so as to pass inhaled and exhaled gases therethrough as the subject breathes;

a flow tube forming a flow pathway for passing inhaled and exhaled gases therethrough as the subject breathes, wherein one end of the flow tube is operatively connected to the respiratory connector and the other end of the flow tube is open, and a wall of the flow tube includes an opening;

a flow meter adapted to generate a signal as a function of the instantaneous volume of inhaled and exhaled gases in the flow pathway, wherein said flow meter is in fluid communication with the flow pathway via the opening in said flow tube;

an oxygen sensor operative to generate a signal as a function of the instantaneous fraction of oxygen in the inhaled and exhaled gases in the flow pathway, wherein said oxygen sensor is in fluid communication with the flow pathway via the opening in said flow tube; and

a processor for receiving said signals from said flow sensor and said oxygen sensor and using the signals to determine the oxygen consumption of the subject over a period of time.

2. The indirect calorimeter of claim 1 wherein said oxygen consumption is determined from the integral of the instantaneous flow volume during inhalation, multiplied by the instantaneous oxygen content measured at the time of measuring the instantaneous flow volume, and subtracting from that integral the integral of the instantaneous flow volume during exhalation multiplied by the instantaneous oxygen content measured at the time of measuring the instantaneous flow volume.

3. The indirect calorimeter of claim 1 wherein said flow tube is a U-shaped member having a first end operatively connected to the respiratory connector, an elongated measurement section, and a second end that is open.

4. The indirect calorimeter of claim 1 wherein said respiratory connector is a mask having a free edge which forms a seal about a portion of a subject's face.

5. The indirect calorimeter of claim 1 having a disposable portion operatively connected to a nondisposable portion, wherein said disposable portion includes said respiratory connector and said flow tube, and said nondisposable portion includes said flow meter, oxygen sensor, and processor.

6. The indirect calorimeter of claim 5, wherein said nondisposable portion includes a housing having an integrally formed support member for

operatively supporting a measurement section of the flow tube, and the support member includes an interlocking upper section and lower section, with the upper section and lower section each forming a semi-cylindrical tube half.

7. The indirect calorimeter of claim 6, wherein said flow meter is supported on either one of said interlocking upper section or said lower section, so that the flow meter projects into the opening in the flow tube.

8. The indirect calorimeter of claim 7 wherein a microbial filter covers a surface of the flow meter.

9. The indirect calorimeter of claim 1, wherein said flow meter is a bi-directional flow meter.

10. The indirect calorimeter of claim 9, wherein said bi-directional flow meter is an ultrasonic flow meter.

11. The indirect calorimeter of claim 6, wherein said oxygen sensor is supported on either one of said interlocking upper section or said lower section, so that the oxygen sensor projects into the opening in the flow tube.

12. The indirect calorimeter of claim 11, wherein a microbial filter covers a surface of the oxygen sensor.

13. The indirect calorimeter of claim 1, wherein said oxygen sensor is a fluorescence quench oxygen sensor.

14. The indirect calorimeter of claim 1, wherein said processor includes a keyboard and a visual display.

15. The indirect calorimeter of claim 1, having a disposable portion operatively connected to a nondisposable portion that is operatively in communication with a remotely located processor, wherein said respiratory connector forms the disposable portion, and said flow meter and oxygen sensor form the nondisposable portion.

16. The indirect calorimeter of claim 1 wherein the flow of respiratory gas through the flow tube is sensed by said processor, which initiates measurement of respiratory gases when the flow of respiratory gas meets a predetermined measurement criteria.

17. The indirect calorimeter of claim 1, wherein said processor calculates the subject's carbon dioxide production over a period of time in accordance with the following equation:

$$V_{CO2} = [V_E - (V_E \circ F_E O_2)] - [V_I - (V_I \circ F_I O_2)].$$

18. An indirect calorimeter for measuring the metabolic activity of a subject comprising:

a disposable portion having a respiratory connector operative to be supported in contact with the subject, so as to pass inhaled and exhaled gases therethrough as the subject breathes, and a flow tube forming a flow pathway for passing inhaled and exhaled gases therethrough, wherein one end of the flow tube is operatively connected to the respiratory connector and the other end of the flow tube is open, and a wall of the flow tube includes an opening; and

a nondisposable portion operatively connected to the disposable portion, having a flow meter in fluid communication with the flow pathway via the opening in said flow tube and adapted to generate a signal as a function of the instantaneous volume of inhaled and exhaled gases in the flow pathway, an oxygen sensor in fluid communication with the flow pathway via the opening in said flow tube and operative to generate a signal as a function of the instantaneous fraction of oxygen in the inhaled and exhaled gases in the flow pathway, and a processor for receiving said signals from said flow sensor and said oxygen sensor and using the signals to determine the metabolic activity of the subject.

19. The indirect calorimeter of claim 18 wherein the metabolic activity is oxygen consumption as determined from the integral of the instantaneous flow volume during inhalation, multiplied by the instantaneous oxygen content measured at the time of measuring the instantaneous flow volume, and

subtracting from that integral the integral of the instantaneous flow volume during exhalation multiplied by the instantaneous oxygen content measured at the time of measuring the instantaneous flow volume.

20. The indirect calorimeter of claim 18 wherein said flow tube is a U-shaped member having a first end operatively connected to the respiratory connector, an elongated measurement section, and a second end that is open.

21. The indirect calorimeter of claim 18 wherein said respiratory connector is a mask having a free edge which forms a seal about a portion of a subject's face.

22. The indirect calorimeter of claim 18, wherein said nondisposable portion includes a housing having an integrally formed support member for operatively supporting a measurement section of the flow tube, and the support member includes an interlocking upper section and lower section, with the upper section and lower section each forming a semi-cylindrical tube half.

23. The indirect calorimeter of claim 22, wherein said flow meter is supported on either one of said interlocking upper section or said lower section, so that the flow meter projects into the opening in the flow tube.

24. The indirect calorimeter of claim 23 wherein a microbial filter covers a surface of the flow meter.

25. The indirect calorimeter of claim 22, wherein said flow meter is a bi-directional flow meter.

26. The indirect calorimeter of claim 25, wherein said bi-directional flow meter is an ultrasonic flow meter.

27. The indirect calorimeter of claim 22, wherein said oxygen sensor is supported on either one of said interlocking upper section or said lower section, so that the oxygen sensor projects into the opening in the flow tube.

28. The indirect calorimeter of claim 27 wherein a microbial filter covers a surface of the oxygen sensor.

29. The indirect calorimeter of claim 18, wherein said oxygen sensor is a fluorescence quench oxygen sensor.

30. The indirect calorimeter of claim 18, wherein said processor includes a keyboard and a visual display.

31. The indirect calorimeter of claim 18 wherein the flow of respiratory gas through the flow tube is sensed by said processor, which initiates measurement of respiratory gases when the flow of respiratory gas meets a predetermined measurement criteria.

32. The indirect calorimeter of claim 18, wherein said processor calculates the subject's carbon dioxide production over a period of time in accordance with the following equation:

$$V_{CO2} = [V_E - (V_E \circ F_E O_2)] - [V_I - (V_I \circ F_I O_2)].$$

33. An indirect calorimeter for measuring the metabolic activity of a subject comprising:

a disposable portion having a respiratory connector operative to be supported in contact with the subject, so as to pass inhaled and exhaled gases therethrough as the subject breathes, and a flow tube forming a flow pathway for passing inhaled and exhaled gases therethrough, wherein one end of the flow tube is operatively connected to the respiratory connector and the other end of the flow tube is open, and a wall of the flow tube includes an opening;

a nondisposable portion operatively connected to the disposable portion, having a flow meter in fluid communication with the flow pathway via the opening in said flow tube and adapted to generate a signal as a function of the instantaneous volume of inhaled and exhaled gases in the flow pathway, an oxygen sensor in fluid communication with the flow pathway via the opening in

said flow tube and operative to generate a signal as a function of the instantaneous fraction of oxygen in the inhaled and exhaled gases in the flow pathway; and

a processor for receiving said signals from said flow sensor and said oxygen sensor and using the signals to determine the metabolic activity of the subject.

34. The indirect calorimeter of claim 33 wherein the metabolic activity is oxygen consumption as determined from the integral of the instantaneous flow volume during inhalation, multiplied by the instantaneous oxygen content measured at the time of measuring the instantaneous flow volume, and subtracting from that integral the integral of the instantaneous flow volume during exhalation multiplied by the instantaneous oxygen content measured at the time of measuring the instantaneous flow volume.

35. The indirect calorimeter of claim 33 wherein said flow tube is a U-shaped member having a first end operatively connected to the respiratory connector, an elongated measurement section, and a second end that is open.

36. The indirect calorimeter of claim 33 wherein said respiratory connector is a mask having a free edge which forms a seal about a portion of a subject's face.

37. The indirect calorimeter of claim 33, wherein said nondisposable portion includes a housing having an integrally formed support member for operatively supporting the measurement section of the flow tube, and the support member includes an interlocking upper section and lower section, with the upper section and lower section each forming a semi-cylindrical tube half.

38. The indirect calorimeter of claim 37, wherein said flow meter is supported on either one of said interlocking upper section or said lower section, so that the flow meter projects into the opening in the flow tube.

39. The indirect calorimeter of claim 38 wherein a microbial filter covers a surface of the flow meter.

40. The indirect calorimeter of claim 33, wherein said flow meter is a bi-directional flow meter.

41. The indirect calorimeter of claim 40, wherein said bi-directional flow meter is an ultrasonic flow meter.

42. The indirect calorimeter of claim 37, wherein said oxygen sensor is supported on either one of said interlocking upper section or said lower section, so that the oxygen sensor projects into the opening in the flow tube.

43. The indirect calorimeter of claim 42 wherein a microbial filter covers a surface of the oxygen sensor

44. The indirect calorimeter of claim 33 wherein said oxygen sensor is a fluorescence quench oxygen sensor.

45. The indirect calorimeter of claim 33, wherein said processor includes a keyboard and a visual display.

46. The indirect calorimeter of claim 33 wherein the flow of respiratory gas through the flow tube is sensed by said processor, which initiates measurement of respiratory gases when the flow of respiratory gas meets a predetermined measurement criteria.

47. The indirect calorimeter of claim 33, wherein said processor calculates the subject's carbon dioxide production over a period of time in accordance with the following equation:

$$V_{CO2} = [V_E - (V_E \bullet F_E O_2)] - [V_I - (V_I \bullet F_I O_2)].$$